

# Trust-based information system architecture for personal wellness

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**Abstract.** Modern eHealth, ubiquitous health and personal wellness systems take place in an insecure and ubiquitous information space where no predefined trust occurs. This paper presents novel information model and an architecture for trust based privacy management of personal health and wellness information in ubiquitous environment. The architecture enables a person to calculate a dynamic and context-aware trust value for each service provider, and using it to design personal privacy policies for trustworthy use of health and wellness services. For trust calculation a novel set of measurable context-aware and health information-sensitive attributes is developed. The architecture enables a person to manage his or her privacy in ubiquitous environment by formulating context-aware and service provider specific policies. Focus groups and information modelling was used for developing a wellness information model. System analysis method based on sequential steps that enable to combine results of analysis of privacy and trust concerns and the selection of trust and privacy services was used for development of the information system architecture. Its services (e.g. trust calculation, decision support, policy management and policy binding services) and developed attributes enable a person to define situation-aware policies that regulate the way his or her wellness and health information is processed.

**Keywords.** Wellness information, modelling, trust, privacy, information system architecture

## Introduction

Healthcare systems currently perform a paradigmatic change where the focus is patient's holistic health and wellness management. The new paradigm is focused on preventive care, proactive services, and early detection of diseases, health promotion and maintenance, but it also supports healthy lifestyles [1-5]. The ubiquitous computing technology and the latest developments of the Internet have not only strong impacts to the ways healthcare services are offered but they have also enabled the rise of a new concept, ubiquitous health, that takes place in ubiquitous environment and therefore creates trust and privacy challenges that do not exist in the current regulated healthcare environment [5-7]. Therefore, a novel privacy management solution that takes into account features of ubiquitous environment, rich health information collected and used and the lack of predefined trust is needed.

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This paper studies ubiquitous health and personal wellness as meta-systems and ties together the results of our research on personal wellness information modelling and on trust-based information system architecture carried out during 2009-2012 [5, 8-14].

## 1. Methods

A holistic system theoretical approach was used to understand ubiquitous health as a concept, its features and trust and privacy concerns. First, an analysis of previous research concerning ubiquitous environment and systems was done. Thereafter, stepwise analysis and system-theoretical framework modelling were used to recognise the stakeholders, viewpoints and interconnections existing in the ubiquitous health and to develop novel privacy principles for it [5].

In personal wellness information modelling, literature analysis, context analysis and focus group methods were used. With literature analysis, we analysed the conceptualisations of personal wellness and personalised healthcare. We searched the following databases: ACM, ESBCOhost Academic Search Premier, IEEE, PubMed, ScienceDirect, SpringerLink and Google Scholar. For the final analysis 100 scientific articles were included. Context analysis with requirements elicitation techniques was applied to identify internal and external contexts for personal health. Regarding focus groups, four groups with six meetings and up to 10 participants, were used to understand how citizens understand the concept personal wellness, how they conceptualise it, and which factors are considered important for personal wellness [9].

The information architecture was developed by combining systems theory, systems engineering, requirements analysis and systems design. First, trust and privacy models was selected and principles developed in such a way they were in line with the general privacy principles and legislation, but at the same time took into account the identified features of the ubiquitous environment. Next, functional requirements and services were developed on the basis of earlier research analysis. Based on the selected principles, models and identified functional requirements the architectural services and their interconnections were developed using systems analysis methods [12-13]. Finally we carried out a feasibility study with a personal health case to assess whether the defined trust and privacy models apply. We used as a method a user-scenario with a detailed walk-through to assess whether the privacy models give a person means to control the access and disclose of his/her personal health information (PHI). We also defined relevant privacy attributes for the components based on literature analyses and empirical research [14].

## 2. Results

In this research, pervasive health is understood as a meta-system, and it is defined to be a network of systems offering health and wellness services for the person (the Data Subject) in insecure information space. The novel privacy principles developed give the DS right to verify dynamically the trustworthiness of the service provider and the right to use personal policies to manage the way health and wellness information is processed. Furthermore, service providers have the responsibility to support the transparency and openness and therefore publish domain specific information required for trust calculation.

The developed personal wellness model consists of five internal components and the two external components social networks and environment. All these components are linked together, which reflects the complete and holistic nature of personal wellness [8-9]. The lifestyle component includes concepts concerning activities, behaviours, choices and risk factors related to the person's lifestyle. Emotional and mental wellness focuses on individual identity, psychological concepts, intellectual wellness, emotions, feelings, person's views and values. Occupational wellness concerns person's well-being at work, in studies, in unemployment or in retirement. Physiological wellness is about health and wellness, i.e. health status and conditions, diseases, disabilities, functioning, genetics, personal observations, monitoring and measuring of health data. The healthcare component presents the healthcare system, its services and systems, their accessibility, service providers and medical documentation. These five internal components are surrounded and affected by external components social networks and environment. Social networks include all social relations that affect a person, including digital social media connections and activities. Environment presents the digital and the physical environment related to a person, i.e. living environment, service environment, society, cultural environment and society regulations and norms. The environment is very flexible and dynamic and it may change over time [8-9].

The analysis of the features and privacy concerns showed that the widely used predefined and static regulatory privacy model of healthcare is insufficient. Instead, a model where privacy is a personal property should be used. This finding is in line with the developed privacy principles [12-13]. We found that in ubiquitous health a person needs rich service provider-specific trust information to make privacy decisions.

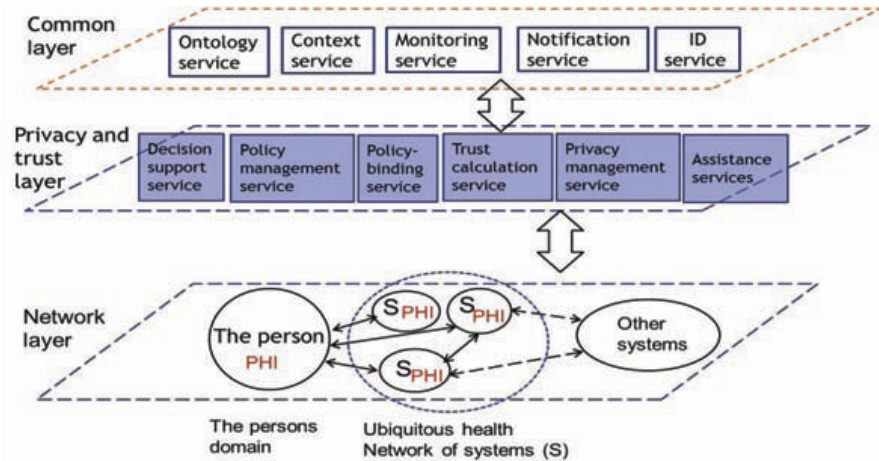


Figure 1: The framework model for the trust-based architecture [13]

The developed 3-layer model for privacy architecture is shown in Figure 1. The top layer consists of common services, and the middle layer includes privacy and trust services. The stakeholders, other users (e.g. secondary users) and personal health information are located at the lowest layer [13]. The trust calculation service offers for the DS rich context-aware trust information in the form of a calculated trust value and trust attributes. Trust attributes describe the level systems support awareness and transparency and how they follow privacy regulations and laws (e.g. EU-privacy relations and national data protection acts). The architecture mimics the way humans

use trust and therefore final trust decision is made by the DS. The role of the policy binding service is to help the DS to formulate computer understandable privacy and security policies. The notification service sends those policies to service providers.

In the feasibility study, we walked through the selected four wellness information model components, and in the scenario we used the person's privacy attributes defined for each component based on literature study and empirical research [5,12-14]. The walk-through showed that when information is transferred from a regulated system to a non-regulated system in pervasive environment, information is considered to be reliable when the person trusts that the sufficient procedures, safeguards and standards have been implemented in the regulated system. After the data is transferred, however, the original data security and privacy policies and values of privacy attributes are no more valid. In a pervasive environment it is difficult for a person to know exactly the actual privacy status of the service or the service provider. This is especially the case when a service provider is a non-regulated one such as in the lifestyle component, or with social networks or with non-certified Internet service providers.

### **3. Discussion**

The developed principles, the personal wellness information model, and the privacy management architecture together offer a novel solution for a person to create trust, to select eHealth and eWellness services, and to manage personal privacy in a ubiquitous environment. The information model presents detailed citizen-based information and it addresses the wellness domain from an information systems science perspective and thus presents a starting point to develop personal wellness ontology. Wellness information and trust attributes are used by architecture's trust and privacy services for creating of computer understandable privacy policies. The privacy architecture gives to the DS tools and means to choose personal context-aware privacy policies for each system it is interacting with the help of computational trust information that covers a trust value and system-specific trust attributes. Selected trust attributes inform the DS how health service providers follow privacy regulations and laws regulating the DS's environment (e.g. which laws and how the service provider has implemented, and does it enable external verification of the implementation). A real benefit is that the architecture offers protection for the DS against many of privacy threats caused by the use of ubiquitous computing and unsecure environments.

The feasibility assessment showed that it is necessary that the DS is always informed of the privacy status of the services he/she is using and the DS can control the way data is processed. For example, specific privacy rules and services are needed for non-regulated environments if they are integrated or communicate with regulated health care services. We applied the self-regulating policies by defining the privacy attributes for each concept in the personal wellness information model. A rich set of context-aware privacy and trust services are offered the DS for trust building and privacy policy creation.

This research has resulted in models and methods for a person to be aware of and to manage the privacy of his/her personal health and wellness information. The results are still to be implemented and make them available and accessible for citizens. Implementation is important as many studies [15-17] indicate that privacy is a top reason for citizens' reluctance to adopt personal health systems.

The next step in our research is to develop a matrix that links trust attributes and privacy policies together. Policies should be easy to understand (i.e. an ontology is needed) and use in real life, and they should offer practical protection against privacy concerns existing in ubiquitous health and wellness [18].

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